STATUS OF SHIP WAKES IN SAR IMAGERY

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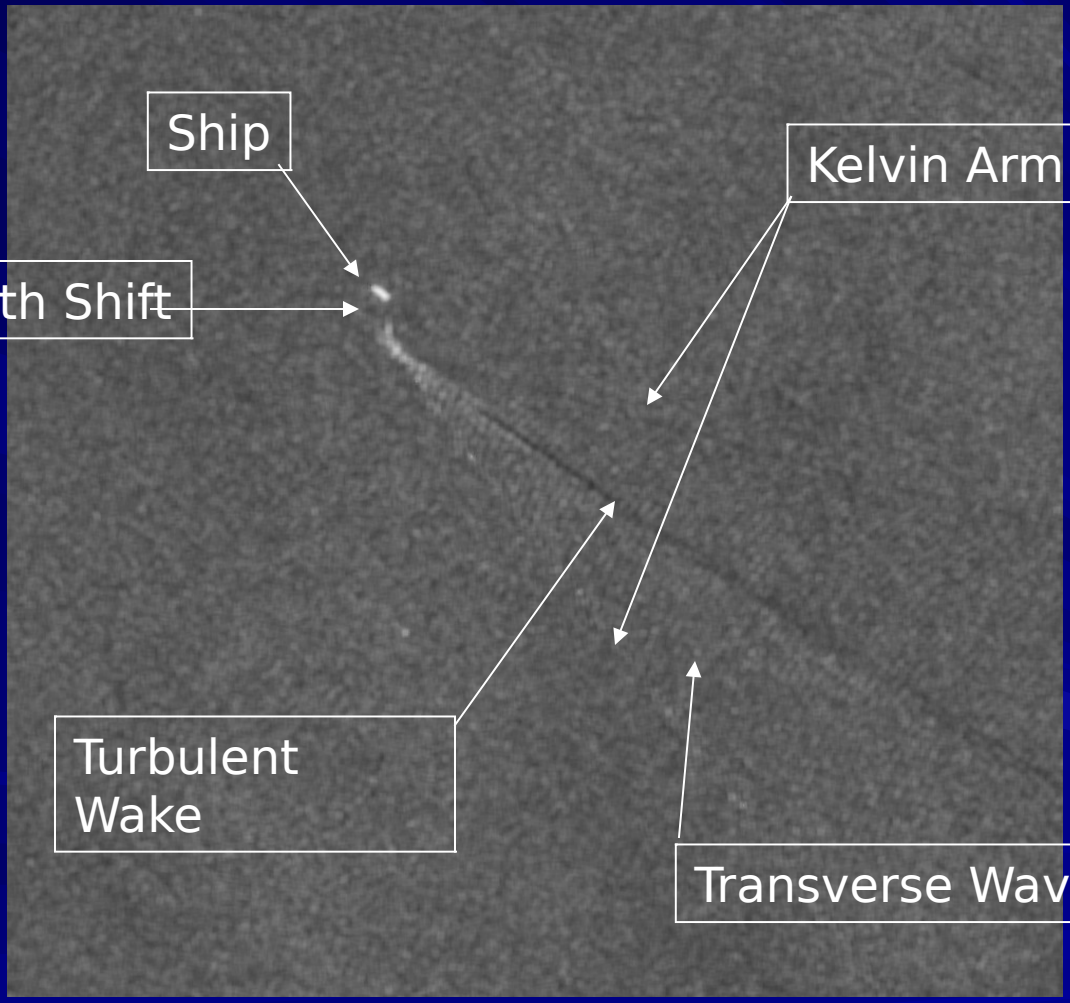
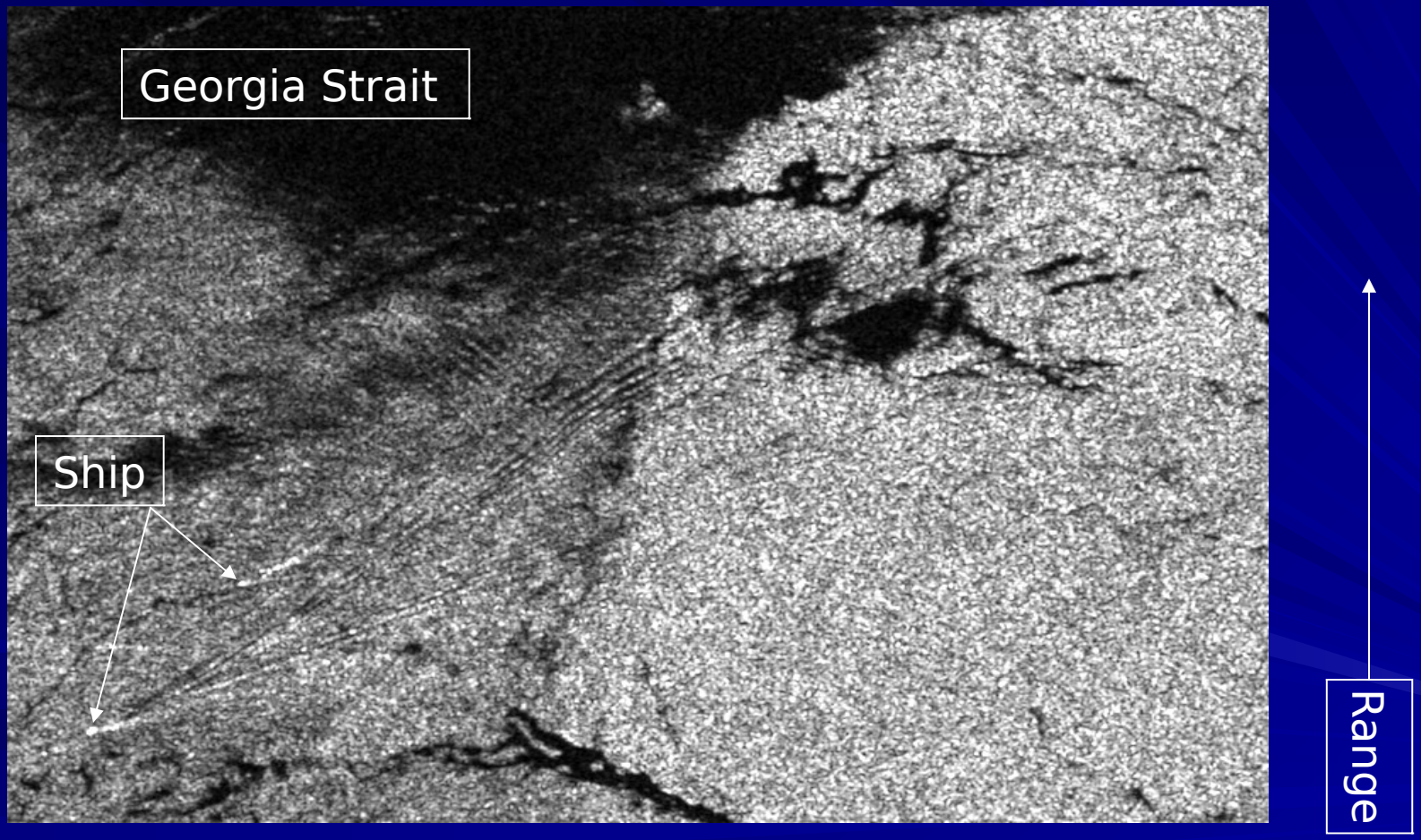
BACKGROUND

- Contribute to Maritime Domain Awareness
  - Extraction of Independent Target Parameters
  - Confirmation/Validation of other Data (AIS)
- Need better Understanding of Ship Wakes
- Program of Study started at RMC, Kingston
  - RADARSAT-2 Images
  - AIS Traffic Pattern Analysis
    - Compare Open Ocean with Lake Ontario/Seaway

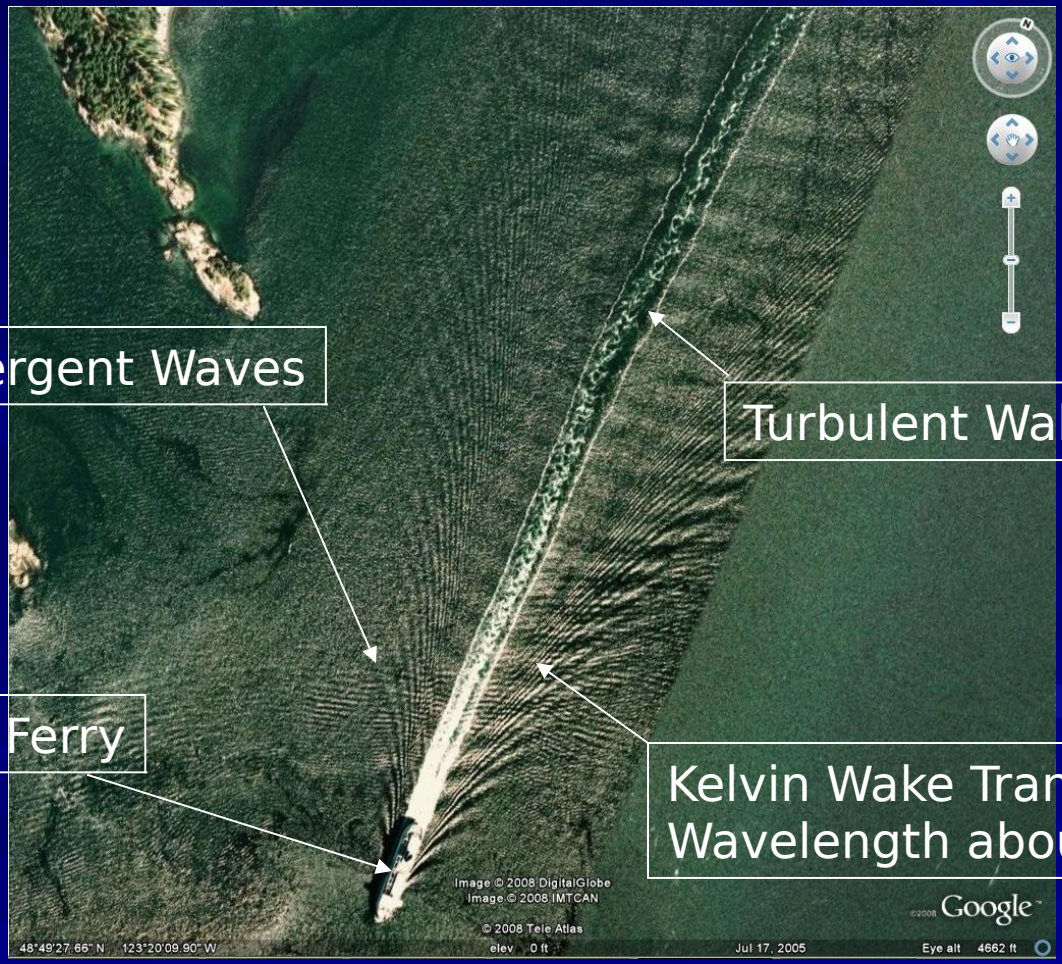
RADAR WAKE


Ship
Kelvin Arm
Azimuth Shift
Range
Turbulent Wake
Transverse Waves

INTERNAL WAVE WAKES



OPTICAL WAKE



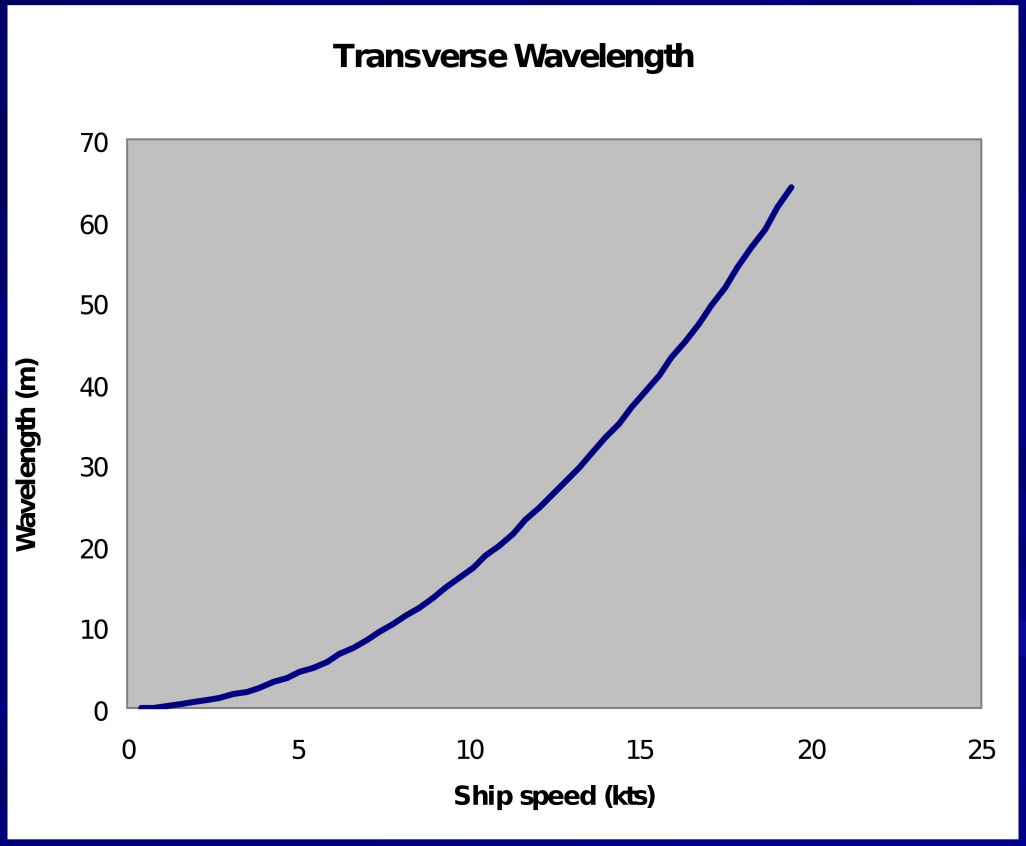
OUTLINE

- Information from Wakes
- Gravity Wakes (Deep and Shallow Water)
  - Kelvin
  - Internal
  - Unsteady (Surface and Internal)
- Turbulent Wake
- Surface Scattering
- SAR Effects

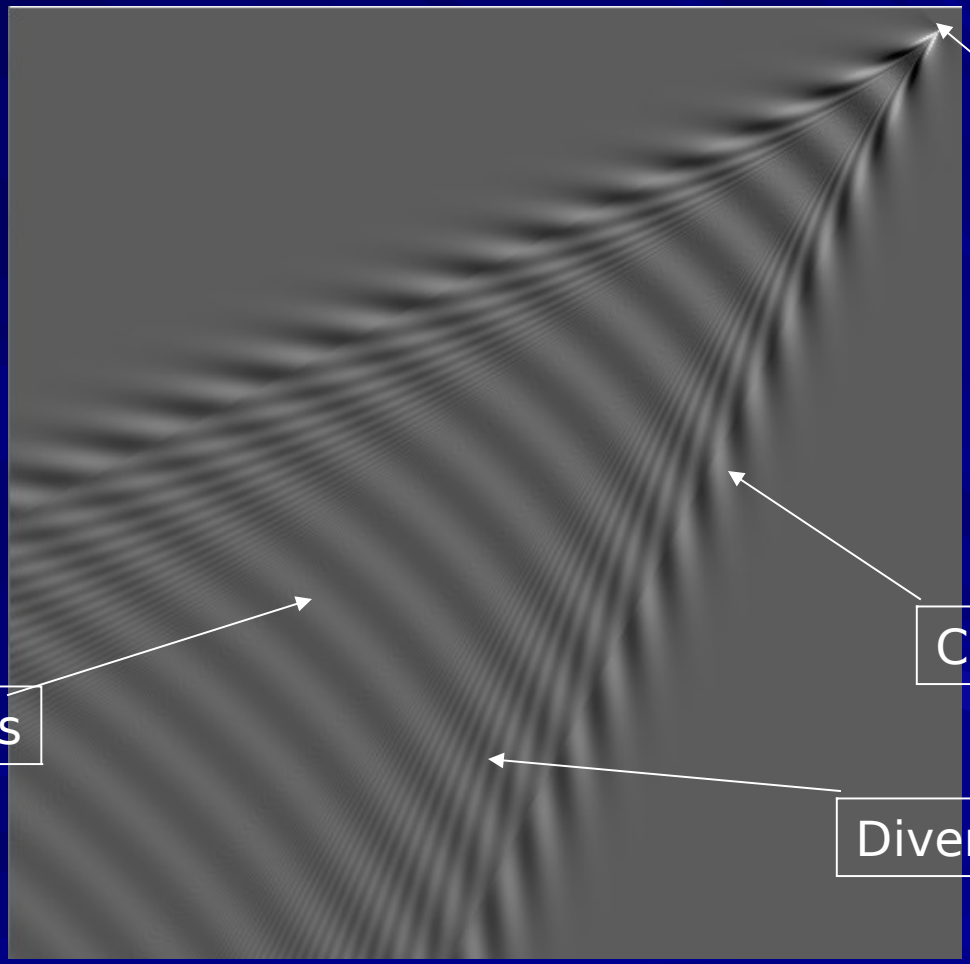
WAKE INFORMATION

- Ship Course
- Ship Speed
  - From Wake Offset
  - From Kelvin Transverse Wavelength
- Potential for Information about:
  - Propulsion System
  - Hull Form/Damage

KELVIN WAVELENGTHS

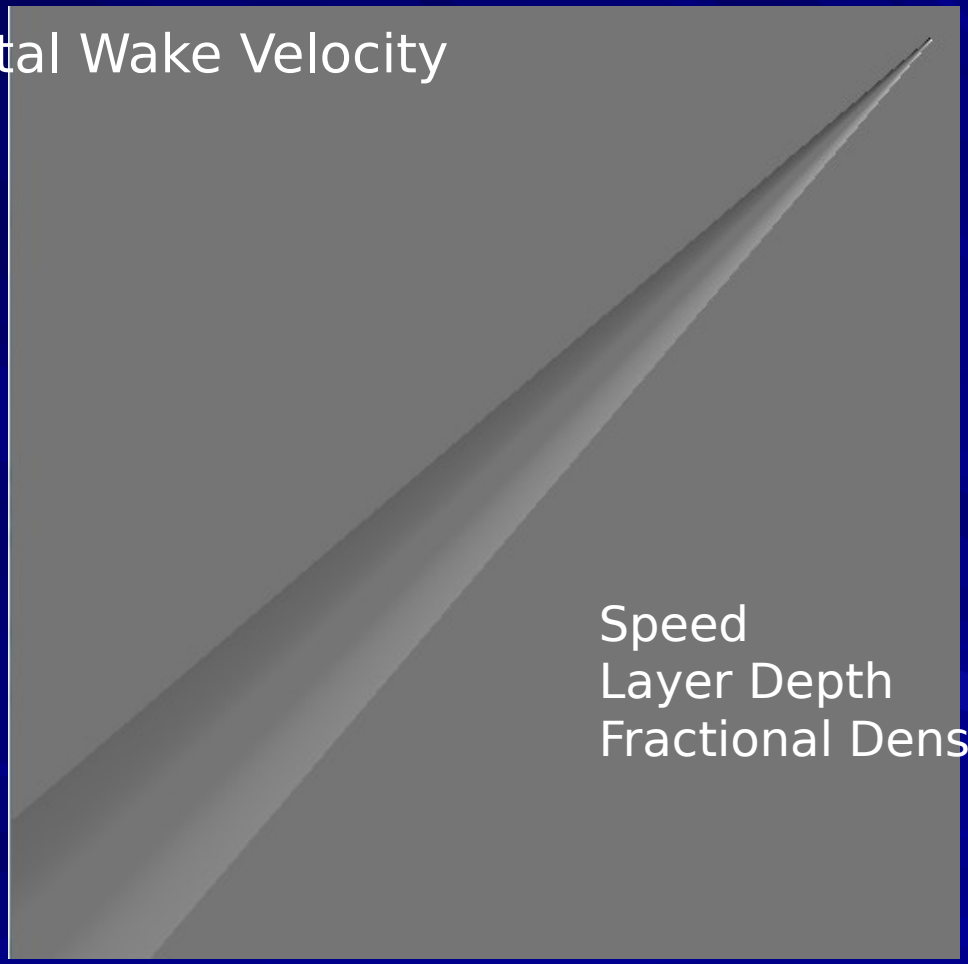


SIMULATED KELVIN WAKE



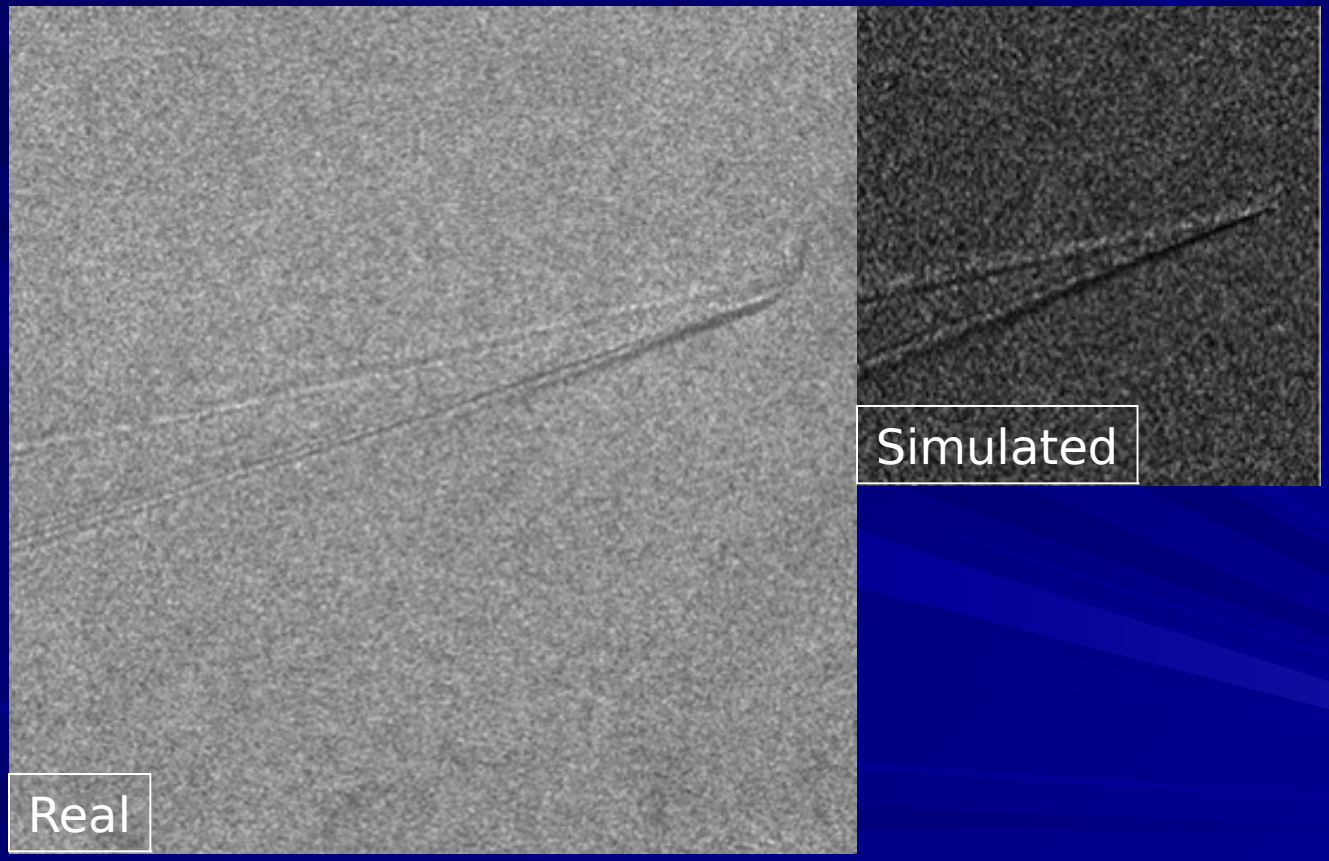
SIMULATED INTERNAL WAKE

Plot of Horizontal Wake Velocity Component



Speed = 15 m/s
Layer Depth = 15 m
Fractional Density Change = 0.01

REAL AND SIMULATED

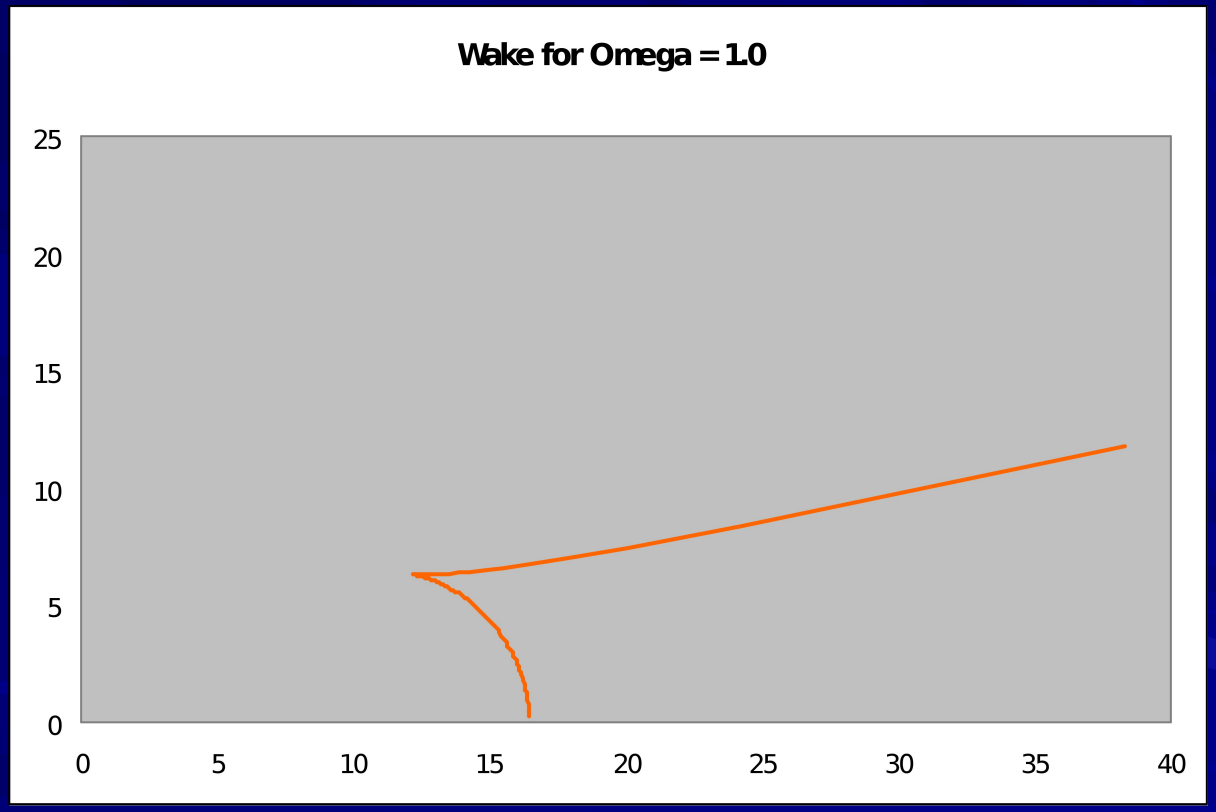


UNSTEADY GRAVITY WAKES

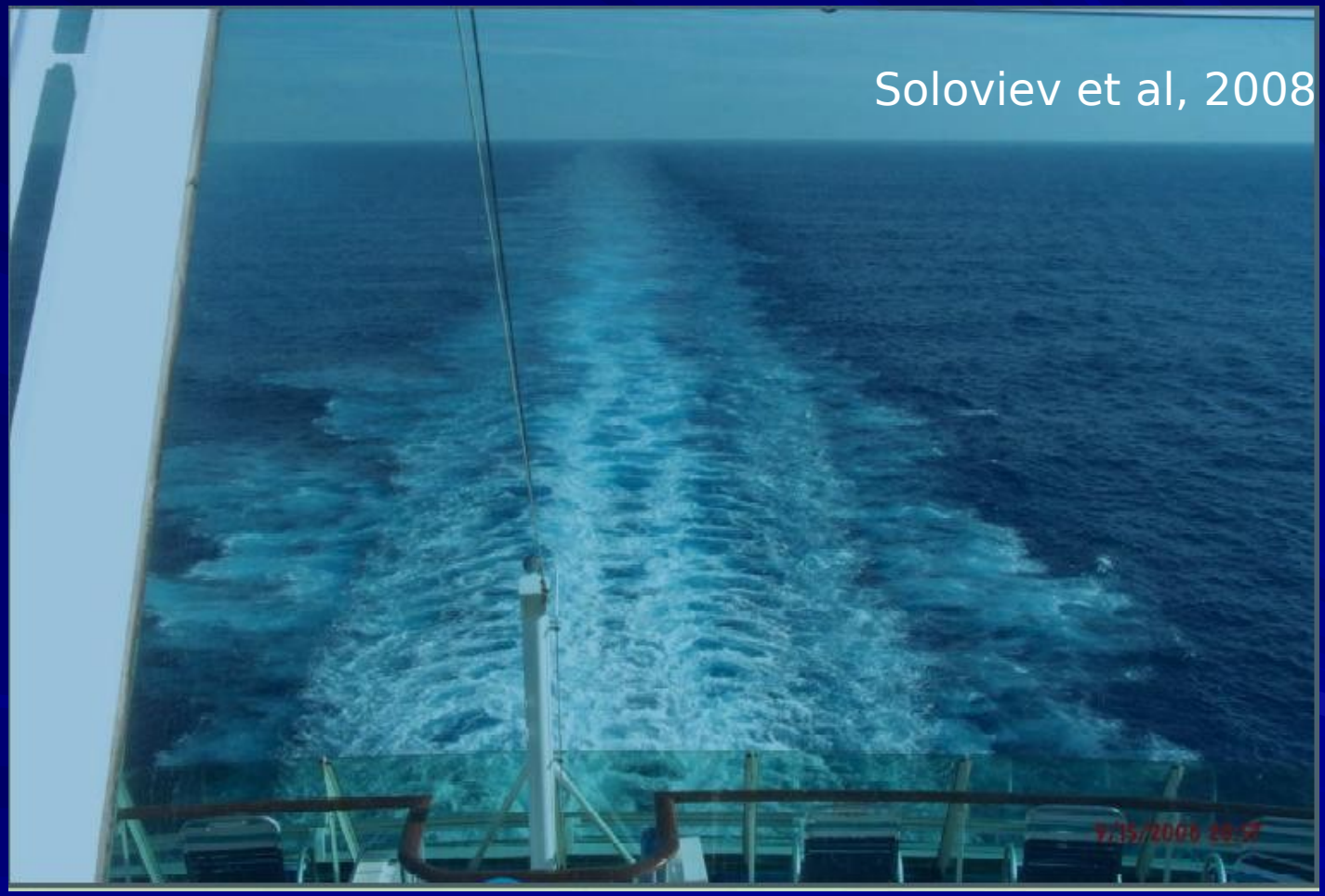
- Sinusoidal (or Random) Excitations
- Excitation due to
  - Heave and Pitch
  - Screws (Blade Frequency)
  - Reflection of Ambient Waves from Hull
- Wake Angle may be much Larger/Smaller than Kelvin Angle (39 degrees)
- Wave Crest Patterns can be Novel

UNSTEADY SINUSOIDAL

Omega = ΩU/g; Critical Omega =0.25



PROPELLER WAKE



TURBULENT WAKE

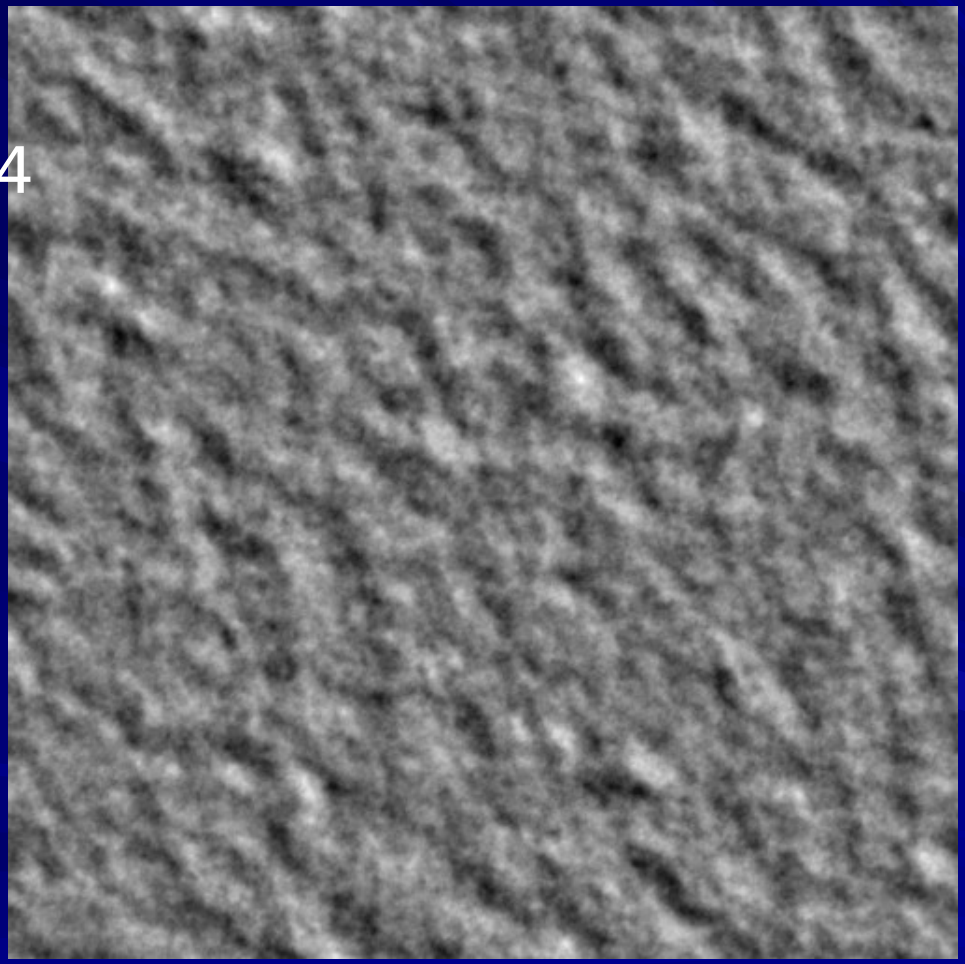
- Comprises Random Vortices
- May contain Steady Flows
- Broadens slowly with Distance Astern, x
- Width, $b = Cx^{1/n}$
- Exponent 1/n depends on Environment and Propulsion

T-WAKE AND PROPULSION

Reciprocal Exponents, n	
Large linear momentum in wake. Under sail.	3
Large angular momentum (swirl). Small linear momentum. Single screw.	4
Negligible mean linear/angular momentum but linear momentum variance high. Under sail at low speed or non-screw propulsion.	≥4
High swirls. Small mean linear and angular momenta. Two contra-rotating screws.	≥5

AMBIENT SEA

Sea State = 4



RADAR SCATTERING

- Bragg Scatter
  - Wright, 1968
- Wave Breaking
- Slope Modulation
- Surface Flows
  - Modify Bragg Waves and Trigger Breaking
- Surfactants

SAR EFFECTS

- Speckle
- Velocity Bunching
- Synthetic Aperture Time (in Ultrafine)
- Often Insufficient Resolution
  - Moire Fringe Effects due to Aliasing
- Bragg Wave Velocities (in Ultrafine)

TRAFFIC FROM AIS

Aug 6th, 2008
6:58LT

CONCLUSIONS

- Wake Theory to be Validated and Completed
  - Basics, Simulations and Visibility
- Inverse Problem Unexplored
- Significant Potential for MDA in Cross-Validation
  - Ship Velocity
  - Low Grade but Valuable Information for Fusion
  - Does not compensate for no AIS Fusion

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